STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

CORROSION STUDY OF CHAIN LINK AND BARBED WIRE FENCING IN COASTAL EXPOSURES

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Mr. L. R. Gillis
Division of Highways
Sacramento, California

Dear Mr. Gillis:

Submitted for your information is a second progress report covering three locations (Silver Strand State Park, Huntington Beach State Park, and South San Francisco) of a

CORROSION STUDY OF

CHAIN LINK AND BARBED WIRE FENCING

IN COASTAL EXPOSURES

Study made by . . . . . Structural Materials Section
Under the direction of . . . . . J. L. Beaton
Work supervised and report by . . . . . R. F. Stratfull

Very truly yours,

F. N. Hveem
Materials and Research Engineer

RFS:mw
cc: FEBaxter
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Jack Smith, Dist. IV
FBCorrea, Dist. VII
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INTRODUCTION

The purpose of this study is to determine the relative service life of various fencing materials and types.

The first progress report on this investigation was dated June 10, 1959.

This corrosion test program was developed with the cooperation of the Division of Beaches and Parks. The test sites are located in State Parks at Huntington Beach and the Silver Strand and on Division of Highways property near South San Francisco.

The observation and repair of excessive corrosion of galvanized steel fencing after a few years of coastal exposure is not a new experience to either the Division of Highway or Beaches and Parks. In fact, an example was reported by District XI in 1957 in which a galvanized fence installed along the Silver Strand had undergone heavy corrosion in less than one year of service.

With the advent of the more common usage of aluminum and copper-clad steel wire (Copperweld) as fencing materials, a test program on the corrosion resistance of these materials compared to galvanized steel was authorized in 1957. The following is a second progress report on the observed condition of the fence materials after approximately 33 months of exposure. Further reports will be made later.

SUMMARY OF TEST RESULTS

The Huntington Beach State Park and the Silver Strand State Park are more corrosive locations than the one at South San Francisco.

It does not presently appear that there will be sufficient economic gain if the more costly aluminum or copper-clad wires are substituted for galvanized barbed wire. The corrosion rate of the three metals formed into barbed wire indicates that all three will probably fail from corrosion in approximately five years at the two more corrosive locations. However, the service life would have been increased if larger diameter wires had been used. The test results indicate that no matter what type of material is used for barbed wire fencing, it will not serve as barbed wire for any appreciable period, except at relatively noncorrosive locations. This appears to be a consequence of the normally small diameter strands used in the manufacture of barbed wire. After the first six months, both the aluminum and copper-clad wire have a better appearance than does the galvanized steel in that the latter is discolored by reddish brown rust.

For chain link fence, it appears that fabric made of copper-clad "Copperweld" wire or aluminum wire may have an economic advantage over the use of galvanized steel. However, the copper-clad and the aluminum metals will require further observations before they definitely can be recommended as a substitute for galvanized steel.

The test results show that when chain link fence is to be constructed in corrosive locations, all parts of the fence should be made of the same metal.

Based on the observations of the highly variable corrosion rates of galvanized steel fences in coastal locations, it appears that it might be more economical to construct the fences originally on a first cost basis, and if necessary replace any corroded fencing on a "spot" basis with a more corrosion resistant material.

At present, sufficient data are not available to recommend a metal that would be an over-all economic substitute for galvanized steel for use as a fencing material.

DISCUSSION

One of the obvious conclusions that can be reached from this study is that none of the tested metals is inert to a corrosive marine environment. Even though the copper-clad steel wire appeared to be highly resistant to corrosion, the failure of the barbed wire strands indicates that the life of this material is highly dependent upon the thickness of the copper. The thicker the copper, the longer the service life.

Appearance-wise, the aluminum was the most corrosion resistant material. However, in the case of the Alloy 5052 aluminum, when the strands were bent by hand they easily broke. This was the result of pitting of the metal. The corrosion resistance of aluminum wire is highly dependent upon the type of alloy. For instance, the tested Alclad Alloy 5056 wire thus far is greatly superior to the Alloy 5052. From this, and the knowledge that "aluminum wire" is being manufactured from numerous alloys, the selection of the type of wire for aluminum fences will require additional investigation before a definite alloy recommendation can be made.

At the present, the existing test sites which are utilized have been obtained through the cooperation of the Division of Beaches and Parks. They are at exposed locations in which vandalism could nullify a test program. The acquisition of permanent test sites would enable the laboratory to expose common highway materials at definite environmental locations where vandalism could be restrained. In addition these locations would encompass a sampling of atmospheric environments throughout the state. It is contemplated that the permanent test sites could include (1) the Sierra Nevadas, (2) an arid desert region in the sand storm area, (3) arid desert region of high humidity caused by irrigation, (4) Southern Sea Coast, and (5) Northern Coast.

It has also been considered that the steel for chain link fence should contain a minimum of 0.20 percent of copper for added corrosion resistance. At the present time our specifications do not contain a chemical limitation for steel utilized for fences. In the reported corrosion tests of copper bearing against non-copper bearing steel, it has been shown that the corrosion rate of copper bearing steel is about 15% less in the tropics and an average of 35% less than mild carbon steel along the east coast of the United States. In one reported case, steel containing 0.20% copper exhibited about one tenth of the corrosion rate of non-copper bearing steel.

The Metallurgical Department of the United States Steel Company in San Francisco was contacted on the feasibility of using copper bearing steel for chain link fence. It was stated that the copper will increase the bond of the galvanizing

to the steel. Also, they stated that the copper bearing steel can be easily fabricated into chain link fence.

Previously the Division of Highways has looked into the feasibility of using copper bearing steel, but fabricators have indicated that it was too difficult to form. Evidently technology in the field of fabrication or metallurgy has increased in the past few years. It was also brought out by the representative of United States Steel Company that steel containing about 0.10% copper is usually used for chain link fence. Although 0.10% copper is more corrosion resistant than a non-copper alloyed steel, it is not as corrosion resistant as higher alloy contents. For these reasons it appears that the use of a special copper bearing steel may be to the economic advantage of the Division of Highways. Further study will be needed concerning this factor.

(1) A PRELIMINARY ESTIMATE OF THE YEARS OF SERVICE LIFE OF FENCING MATERIALS

Location	Galvanizing			Barbed Wire			Chain Link Fabric				Bi-metallic Couples (5)		
	Barbed Wire	Chain Link Fabric	Posts	Galv. Steel	Aluminum	Copperweld	Galv. Steel	Alloy 5052 Alum.(2)	Alclad 5056 Alum.	Copperweld	Alum. (6) to copper	Alum. (6) to steel	Steel (6) to copper
Huntington Beach (3) State Park	0.5	1	2.5	5	-	-	9	12	15	15	-	2.5	15
South San Francisco	-	5	5	-	-	-	20	15	20	20	10	15	-
Fleishhacker Zoo (4)	-	7	-	-	-	-	15	-	-	20	-	-	-
Silver Strand State Park	0.5	1	4	5	5	5	10	12	15	15	-	2.5	5

Notes:

(1) This table is based upon the visual inspection of the test facilities after an exposure period of 33 months.

(2) Failure will be where wire intermeshes with itself.

(3) Barbed wire removed after approximately 24 months of exposure.

(4) Fence installed by City of San Francisco on December 8, 1954. Exposure is 6 years and 4 months.

(5) The bi-metallic couples are the physical contact of fabrics or tie wires to a fabric or a tie wire of a dissimilar metal.

(6) This is the metal that is being subjected to accelerated corrosion.

SUMMARY

HUNTINGTON BEACH STATE PARK

The latest inspection of this test site was made on April 3, 1961, of the fence which was installed on July 24, 1958, at the Huntington Beach State Park. The observed conditions of the fence sections are as follows:

The service life of galvanized steel barbed wire appears to be less than 5 years.

Alclad type 5056 is more corrosion resistant than type 5052 aluminum.

The service life of galvanizing on the fabric is approximately one year. On barbed wire, the service life of galvanizing is about six months.

Except at the cut ends, the copperweld fabric appears to be the most corrosion resistant material.

Galvanized Fence, Southerly or Leeward Side

The galvanized fabric has 100% of its surface area rusted and approximately 15% of the original thickness of the steel has been lost due to corrosion.

The barbed wire was removed from this fence by the park supervisor in the early part of 1961. Shifting sands caused the ground level to rise and placed the barbed wire at a new elevation that was hazardous to the public. At the time of the inspection of January 13, 1960, the barbed wire was rusted for 100% of its surface area with about a 10% loss of the original metal thickness.

Galvanized Fence, Northerly or Windward Side

The fabric is rusted for 100% of its surface area and has lost approximately 10% of its original thickness of metal.

The galvanized steel top brace has rusted for 100% of its surface area and has lost up to 10% of its original thickness of metal.

Aluminum Fence Alclad Type 5056, Southerly or Leeward Side

As a result of corrosion, the fence is a dull gray in appearance. There are numerous pits in the wire that range from approximately .001" to .025" (observed).

Aluminum Fence, Alclad Type 5056, Northerly or Windward Side

The fence is a dull blackish gray in appearance. There is a heavy coating (.010") of dust and corrosion products covering the surface of the fabric.

Pits of approximately .002" to .004" were observed. There is no accelerated corrosion of the fabric where it meshes.

Aluminum Fence, Type 5052, Southerly or Leeward Side

The fabric is a dull aluminum color in appearance. The fabric is severed by corrosion where it contacts rusted steel.

Aluminum Fence, Type 5052, Northerly or Leeward Side

The fabric is a gray aluminum color in appearance. However, the fabric appears brighter when compared to the Alclad type 5056. Pits of .001" to .003" ± were observed on the surface of the fabric.

Where some of the strands intermesh, the wire has corroded for approximately 0.01".

The aluminum post has some pits of approximately .001".

SOUTH SAN FRANCISCO

The latest inspection was made on April 11, 1961, of the fence which was installed on October 10, 1958. The observed conditions of the fence sections are as follows:

Summary

The service life of galvanizing appears to be approximately 3 years.

The Copperweld fabric appears to be more corrosion resistant than the galvanized steel or aluminum fabric.

At the 30 month inspection, the galvanized steel fabric is in better structural condition than the type 5052 aluminum.

Galvanized Fence, Easterly or Leeward Side

Approximately 30% of the surface of the fabric is rusted. The galvanized steel post has a light rust coating for approximately 30% of its surface area. Structurally, the metal loss of the steel is insignificant.

Galvanized Fence, Westerly or Windward Side

There is a heavy coating (approx. 0.01") of zinc oxide and dust covering the surface of the fabric. Rust was not observed on the surface of the fabric.

Copperweld Fence, Easterly or Leeward Side

The Copperweld fabric has a green oxide coating approximately 0.002" thick. There is no pitting and a negligible amount of rust on the cut ends.

Copperweld Fence, Westerly or Windward Side

The fabric is covered with a copper oxide and dust coating that is approximately .005" thick. There is no significant rusting of steel at the cut ends.

Aluminum Fence, Type 5052 Easterly or Leeward Side

The fabric is relatively bright in appearance. However, there are a few pits of approximately 0.001" in depth. Also, at some of the locations where the strands intermesh, the wire has lost approximately 0.01" of its original thickness.

Aluminum Fence, Type 5052 Westerly or Windward Side

The fabric is dull in appearance and there is approximately 0.005" of aluminum oxide and dust that is coating the surface of the wire. Beneath this coating, there are pits of approximately 0.002" in depth.

There is approximately 15% loss of aluminum metal thickness where it contacts the Copperweld fabric.

Note: A section of Copperweld fence was installed by the City of San Francisco at Fleishhacker Zoo on December 8, 1954. The condition of the fence when inspected on April 11, 1961, is as follows:

At the cut ends, the copper cladding has been peeled back approximately 3/16" as a result of corrosion of the steel core. Otherwise, the fabric is not pitted although there is a copper oxide coating on the fence that is approximately .005" thick.

An adjacent galvanized steel fence which appears to have been installed at about the same time of the Copperweld fence has approximately 95% of its surface area rusted and an estimated 10% corrosion loss of the diameter of the steel wire.

SILVER STRAND STATE PARK

The latest inspection of this test site was made on April 4, 1961, of the fence which was installed on July 30, 1958. The observed conditions of the fence sections are as follows:

Summary

The service life of galvanizing on the fabric at this location is approximately one year.

Of the fabrics, the Copperweld steel is more corrosion resistant than galvanized steel or aluminum.

The Alclad Type 5056 aluminum is more corrosion resistant than the Type 5052 aluminum.

It is considered that the service life of the Type 5052 aluminum will approximate that of galvanized steel.

The service life of barbed wire appears to be equal irrespective of the metal.

Copperweld Fence, Easterly or Leeward Side

A green oxide of approximately 0.003" is covering the metal fabric. There are no pits in the copper. All galvanized steel in contact with the copper has rust covering its entire surface.

At the cut ends of the Copperweld wire, the expanding rust from the corrosion of the steel core has caused the copper cladding to be peeled back from the end of the wire for a distance of about 1/8".

No pitting of the copper cladding was observed.

Copperweld Fence, Westerly or Windward Side

The fabric is covered with a green oxide coating of approximately 0.005" thick. No pitting of the copper was observed beneath the oxide coating.

The galvanized steel tie wires that are in contact with the Copperweld fabric are rusted and have lost approximately 60% of their original metal thickness.

Galvanized Fence, Easterly or Leeward Side

The fabric has 100% of its surface area rusted and metal thickness loss of approximately 10%.

The galvanized top tension cable has rusted for 100% of its surface area and lost approximately 10% of its original metal thickness.

Galvanized Fence, Westerly or Windward Side

The surface of the fabric is completely rusted, and has lost up to approximately 20% of its original metal thickness.

Approximately 25% of the surface area of the galvanized steel post is rusted.

Aluminum Fence, Alclad Type 5056 Easterly or Leeward Side

The fabric is a dull grayish aluminum color in appearance and it is covered with an oxide coating that is approximately 0.001" deep.

At some of the locations where the aluminum fabric is in contact with rusted steel, the aluminum has lost approximately 50% of its original metal thickness to corrosion.

Except for the accelerated corrosion at the bi-metallic contacts, the aluminum had no significant loss of structural section.

Aluminum Fence, Alclad Type 5056 Westerly or Windward Side

The fabric is covered with a dull grayish aluminum oxide coating. Pits of approximately 0.001" deep were observed.

A perceptible but an insignificant amount of aluminum was observed to be lost where it intermeshes with itself.

At one location the fabric was severed by corrosion where it contacted rusted steel wire.

Aluminum Fence, Type 5052 Easterly or Leeward Side

The fabric is a dull silver color in appearance. When compared to the Type 5056 fabric, this fence could be considered to be bright in appearance. Pits of approximately 0.005" deep were observed in the metal.

At four locations where the aluminum contacted rusted steel, the aluminum was severed as a result of the accelerated bi-metallic corrosion.

Aluminum Fence, Type 5052 Westerly or Windward Side

The fabric has a light coating of aluminum oxide and dust. The fabric is a dull silver color in appearance which makes it brighter than the Alclad Type 5056 fabric.

Pits that were approximately 0.005" deep were observed.

At some locations where the wire is intermeshed, the aluminum is pitted approximately 0.01".

Aluminum Post

The post is a dull silver color in appearance and has some pits which are approximately 0.001" in depth.

Barbed Wire

The top wire is Copperweld, the middle wire is galvanized steel, and the bottom wire is aluminum.

Copperweld Barbed Wire

The copper cladding has been peeled back from the end of the barb for a distance of approximately 1/8". This was caused by the expanding rust from the corrosion of the steel core.

At numerous locations the copper cladding is pitted and has been peeled back on the wire strands. At these same locations the steel core has lost more than 50% of its original dimension.

Galvanized Steel Barbed Wire

The galvanized steel barbed wire has rusted for 100% of its length and lost approximately 20% of its original metal thickness.

Aluminum Barbed Wire

The aluminum wire is a dull silver color in appearance. At one location it was observed that a pit had penetrated the metal for approximately 40% of the original metal thickness.